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Study on Efficiency Sustainability of Taiwan's Bank Performance under a Dynamic Framework

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Abstract

This paper aims to calculate individual bank efficiency based on cross-sectional study data and output-oriented super-efficiency data envelopment analysis model of a slack variable. Then, the panel data model is used to analyze the dynamic efficiency and continuity of the operating performance and to assess the deferred effects of Taiwan's banks as a whole and individually. The empirical result shows that all efficiency values have intertemporal or multistage deferred dynamic sustainability. With a mean value of continuity of all efficiency values of up to 89.39%, the banking industry has a certain dynamic continuity in terms of operating efficiency. The results of this study can not only be used as basis for the adjustment of the salary dividend of an individual chief executive officer but also can be used to verify the short-term influence of major government policies on the economy. In the long term, the results of this study can be used as an indicator of national economic trends and fill existing gaps in the academic field.

JEL classification numbers: D24, D53, E17, E58
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1 Introduction

Financial system operation and performance sustainability have important roles in the assessment of the economic development of a country. The development of financial

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institutions significantly influences the growth of the economy (Gurley and Shaw, 1955; Patrick, 1966; Levine, 1991; Pagano, 1993; Odedokun, 1996). One hundred ninety-six articles on banking performance assessment reviewed by Feith and Pasiouras (2010) indicated that data envelopment analysis (DEA), which is the most extensively used approach in this field, considers, and does not estimate, the important relationship between input and output and the constructed production efficiency frontier. Previous scholars used DEA to study banking efficiency mainly (1) to compare and rank different bank efficiencies and to distinguish high-efficiency and low-efficiency banks (Drake and Hall, 2003; Andries, 2010), (2) to analyze factors that affect bank efficiency (Halkos and Salamouris, 2004), and (3) to compare and study bank efficiency and analyze the root cause of bank efficiency loss (Sathye, 2003).

In connection to research priority with regard to operating efficiency in recent research, the DEA model is generally used to compute and estimate efficiency (Chacar and Vissa, 2005; Lin et al., 2007; Casarin et al., 2008). The DEA model can be used to assess changes in efficiency sustainability. The DEA model (1) can help managers assess the proportion of the salary of the chief executive officer (CEO) (Chen and Rouah, 2009), (2) can help policymakers adjust production technology or operating direction by providing efficiency information (Wang and Huang, 2007), and (3) can measure the corporate profitability or performance sustainability of a country (Chacar and Vissa, 2005; Stierwald, 2009; Andries,2010). For example, Chen and Rouah (2009) assessed CEO performance by studying American banks, and they constructed the CEO's efficiency coefficient during sample observation. The best CEO was paid a higher salary than low-performing CEOs. Wang and Huang (2007) used DEA combined with the panel data model and Markov model to assess the sustainability of the economic efficiency of Taiwan's commercial banks. The empirical result showed that bank efficiency had mild sustainability during sample observation. This finding indicates that banks cannot adjust their production technology in time series features immediately to improve efficiency value.

Most previous studies used the DEA model in the CCR mode and BCC mode to calculate the efficiency value of the decision making unit (DMU) and structural model, and assessed the factors that affect the inefficiency value of exogenous variables by using the Tobit model and logistic regression model. However, this method did not analyze the dynamic influence of factors (Hughes and Mester, 1998; Altunbas et al., 2000). Later, scholars adopted the Malmquist model[4] to measure the bank dynamic intertemporal DEA total factor productivity (Casu and Girardone, 2004; Tanna, 2009). With a dynamic concept, the model neglects the fact that factors that affect efficiency sustainability may have multiple stages. For example, in their study on the sustainability of bank efficiency, Wang and Huang (2007) adopted the correlation coefficient of the efficiency value to determine if the efficiency value has moderate sustainability. Then, Wang and Huang (2007) used the financial index combined with the panel data model and Markov model to analyze the factors that affect efficiency sustainability. The financial index could prove the sustainability of bank efficiency. However, the financial index was based on statistical

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[4]The Malmquist productivity index is used to measure dynamic interperiod DEA efficiency. The leading edge of production will change by time. As such, we measure total factor productivity, technical change, efficiency change, pure technical efficiency change, and scale efficiency change to examine which factor has an effect.

reasoning only and lacked the strong support of the econometric model. This paper aims to use the cross-sectional study data and output-oriented DEA super-efficiency model of slack variable to compute the individual efficiency of each bank to address the issues that previous literature did not. Then, the panel data model is used to analyze the sustainability of the dynamic efficiency of operating performance and assess the deferred effects of Taiwan's banks as a whole and individually in terms of efficiency.

Before discussing bank operating performance, we must understand institutional factors that banks are compelled to comply with and that cause restrictions in operations and elasticity adjustment. For example, the capital adequacy ratio of a bank should be relatively maintained at 8%[5]. Interest rate adjustment is not determined by the market mechanism completely, but is affected by the government's monetary policy. Ouellette and Vierstraete (2004) have explained that quasi-fixed input exists in every business economy. Even in long-term operation, quasi-fixed input cannot be immediately adjusted to the optimal value. This restriction should be included in the model. Thus, we can perform correct measurements and obtain the correct efficiency value. Therefore, all adjusted quasi-fixed cost and efficiency do not generate the expected results. The results will be reflected in bank performance with the concept of deferred period. We believe that when banks slowly adjust the quasi-fixed input value, changes in its efficiency value will have several relatively deferred periods, that is to say, the bank's operating efficiency has sustainability. The relatively deferred efficiency value can be analyzed and explained by using the time series model. For the unexplained remainder, other exogenous variables should be used to further analyze the factors of efficiency sustainability.

This paper aims to use technical efficiency (TE), pure technical efficiency (PTE), and scale efficiency (SE) to study if all efficiency values of bank operating performance have a sustainable influence. This paper has two objectives. First, it aims to prove that changes in the bank's efficiency value will have several relatively deferred periods, that is, the bank's operating efficiency is sustainable. The bank's operating efficiency can provide the basis for adjusting an individual CEO's salary and dividend and for the investors' reference. Second, the policy department can assess the influence of financial and monetary policies on the performance of financial institutions and can also provide authorities with information to enable them to respond appropriately to financial and monetary policies for adjusting the direction of economic growth.

The rest of this paper is organized as follows: Section 2 introduces the research approach and attempts to determine the existing dynamic adjustment of efficiency sustainability and efficiency value. Efficiency value is obtained by using the super-efficiency model of slack variable in the first stage. Section 3 briefly introduces the source and definition of the variable and explains studies on the efficiency sustainability of Taiwan's banks. Section 4 concludes this paper.

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[5]Basel II defined that the ratio of its own capital (Capital I + Capital II + Capital III) to the risk-weighted asset should be relatively maintained at 8%.

2 2 Research Approach

2.1 Super Slack-based Measure

In traditional DEA models, an efficiency value of 1 is given to DMUs with efficiency. Therefore, many DMUs will have the same efficiency value, which is unfavorable to the study of efficiency sustainability. To rank DMUs with efficiency, Andersen and Petersen(1993) deleted DMUs with efficiency from the data set, and then performed a recalculation based on the remaining DMUs. A new efficiency boundary is formed. The deleted DMUs are not enclosed by the efficiency boundary. After calculating the distance from the deleted DMUs to the new efficiency boundary, the measured new efficiency value will be greater than 1. Thus, ranking the efficiency value will be easy. This method then becomes the concept of super efficiency. Super efficiency can solve the problem in which efficiency values of the original DEA models are all equal to 1. However, Thrall(1996) determined that the super-efficiency model would be infeasible in case of changing returns to scale.

The traditional CCR mode and BCC mode measures ray efficiency. These two modes supposed that input and output could be adjusted to an equal ratio. However, this hypothesis is not valid in many practical situations. Therefore, Tone(2001) proposed the slack-based measure (SBM) mode by using the slack variable as a measurement basis[6]. Similarly, to solve the problem in which SBM efficiency values of multiple decision units are equal to 1, Tone(2002) proposed the modified slack variable model to estimate super-efficiency value of the decision unit, namely, the super SBM. The super SBM can solve the problem in which changing returns to scale cannot be estimated. The super SBM model is described as follows:

1. To define production possibilities, we set $P\setminus(I_0,O_0)$ as follows:

$$P\setminus(I_0,O_0)=\left\langle(\bar{I},\bar{O})\middle|\bar{I}\geq\sum_{j=1}^{n}\lambda_j I_j \quad \bar{O}\geq\sum_{j=1}^{n}\lambda_j O_j \quad \bar{O}\geq 0 \quad \lambda\geq 0\right\rangle \tag{1}$$

2. To define the $P\setminus(I_0,O_0)$ subset, we used the following equation:

$$\bar{P}\setminus(I_0,O_0)=P\setminus(I_0,O_0)\cap\left\{\bar{I}\geq I_0 \quad \text{and} \quad \bar{O}\leq O_0\right\} \tag{2}$$

Suppose that if $I>0$ and $O>0$ and $\bar{P}\setminus(I_0,O_0)$ is not an empty set, then the indicator δ is the weighted average distance from any DMU (I_0,O_0) to $(\bar{I},\bar{O})\in\bar{P}\setminus(I_0,O_0)$ as follows:

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[6]The SBM mode is a non-radial estimation mode, which considers the slack between input and output items. The estimated efficiency values are in the range of 0 and 1. The features of this model are as follows: (1) the efficiency value obtained by using the SBM mode is less than that by using the CCR mode and (2) if each evaluated unit has SBM efficiency, then it definitely has CCR efficiency, otherwise, it does not.

$$\delta = \left[(1/m) \sum_{i=1}^{m} \bar{I}_i / I_{i0} \right] \Big/ \left[(1/s) \sum_{r=1}^{s} \bar{O}_r / O_{i0} \right] \tag{3}$$

As shown in Equation (3), only when $(\bar{I}, \bar{O}) \in \bar{P} \setminus (I_0, O_0)$, that is, after deleting DMU, (I_0, O_0) has no influence on the production possibilities set, $\delta = 1$, if not $\delta > 1$. Based on this assumption, δ^* refers to the super-efficiency value of DMU (I_0, O_0) that was estimated by using the super SBM model. The solution model is expressed as follows:

$$\delta^* = \min \quad \delta = \left[(1/m) \sum_{i=1}^{m} \bar{I}_i / I_{i0} \right] \Big/ \left[(1/s) \sum_{r=1}^{s} \bar{O}_r / O_{i0} \right] \tag{4}$$

s.t.

$$\bar{I} \geq \sum_{j=1,\neq 0}^{n} \lambda_j I_j,$$

$$\bar{O} \geq \sum_{j=1,\neq 0}^{n} \lambda_j O_j,$$

$$\bar{I} \geq I_0 \quad \text{and} \quad \bar{O} \leq O_0,$$

$$\bar{O} \geq 0, \quad \lambda \geq 0.$$

If the super SBM model is modified to calculate the changing returns to scale, the model is expressed as follows:

$$\delta^* = \min \quad \delta = \left[(1/m) \sum_{i=1}^{m} \bar{I}_i / I_{i0} \right] \Big/ \left[(1/s) \sum_{r=1}^{s} \bar{O}_r / O_{i0} \right] \tag{5}$$

s.t.

$$\bar{I} \geq \sum_{j=1,\neq 0}^{n} \lambda_j I_j,$$

$$\bar{O} \geq \sum_{j=1,\neq 0}^{n} \lambda_j O_j,$$

$$\sum_{j=1,\neq 0}^{n} \lambda_j = 1,$$

$$\bar{I} \geq I_0 \quad \text{and} \quad \bar{O} \leq O_0,$$

$$\bar{O} \geq 0, \quad \lambda \geq 0.$$

Under the changing returns to scale, the super SBM VRS model is used to estimate the efficiency value of the decision unit. This model can solve the problems that the efficiency values of the DEA models are equal to 1 and the super-efficiency model cannot be estimated.

2.2 Panel Unit Root Test and Stepwise Regression

To predict Taiwan's banks performance and assess its sustainability, the panel self-regression model of Taiwan's banks m-order efficiency, AR(m), is first used to obtain the linear part as follows:

$$\delta_{i,t} = \mu_i + \sum_{j=1}^{m} \beta_i \delta_{i,t-j} + \varepsilon_{i,t} \tag{6}$$

where $\delta_{i,t}$ refers to the efficiency of the ith banks in Taiwan in t, μ_i refers to the individual fixed effects, δ_{it-j} refers to the lagged period of the ith banks efficiency in Taiwan, and β_i and $\varepsilon_{i,t}$ refer to the sustainability coefficient of the ith bank efficiency in Taiwan and its error term, respectively.

2.3 Panel Data Autoregression

Traditional estimated autoregressive (AR) model usually uses ordinary least squares (OLS). However, this approach can only consider time series or cross-sectional data. In addition, the importance of time series or cross-sectional data can be easily neglected, which causes biased and invalid estimate results. Therefore, this paper adopts the panel-estimated AR model to conduct the empirical analysis. The data of the panel-estimated AR model have two characteristics, namely, time series and cross section. The panel-estimated approach combines cross section with time series, thereby obtaining a special structure of the comparison analysis of inter-group and in-group variation. This special structure is characterized by cross-sectional data that are not changed by time and the variability of variable samples. Therefore, the panel-estimated AR model has better measurement effect and efficiency than the traditional OLS-estimated AR. The content of the model is expressed as follows:

$$Y_{it} = \sum_{j=1}^{N} \alpha_j D_{ij} + \beta X_{kit} + \varepsilon_{it} \tag{7}$$

where i = 1, …, N refers to the cross-sectional samples in the same period, t = 1, …, T refers to the research period, and k = 2, …, K refers to the number of explained variables. D_{ij} refers to the fixed intercept, which means that every cross-section has a different structure indicated by a dummy variable. If i = j, then $D_{ij} = 1$, if j ≠ i, then $D_{jt} = 0$. X_{kit} refers to the observation value of the ith sample in k explained by variables in stage t. ε_{it} refers to the error term, subordinate to i.i.d. $(0, \delta_{\varepsilon}^2)$.

3 Empirical Result and Analysis

3.1 Selection of Input and Output Variables

Compared with the manufacturing industry, the banking industry has more diverse products and services. Control on input factors is easier than on output factors. The bank is an intermediary financial institution that is involved in financial intermediation and uses the funds of depositors to obtain benefits by lending rather than focusing on producing deposits and loans. Therefore, previous scholars mostly used the intermediation approach. Barr et al. (1993); Miller and Noulas (1996) adopted this approach and regarded the loan amount and investment amount as output factors and interest expense, labor, capital, operating expense, and all financial costs as input factors. This approach highlights the characteristics of the bank by using the assess types, scale differences, and multiple outputs of the bank. Wang and Huang (2007) used the intermediation approach and regarded investment, short-term loan, and long-term loan as input items and all deposits, the number of employees, and capitals as output items. This paper selects the input and output variables, adopts the intermediation approach, and integrates the advantages of the findings of each scholar. With regard to the use of deposit, investment, and all loans as output items and interest expense, personnel expense, and operating expense as input items, this paper used quasi-fixed costs as input point to highlight the characteristics of the bank by using the capital, scale differences, and multiple outputs of the bank.

3.2 Data Sources

The study samples were obtained from the Compilation of Financial Business Statistics edited by the Banking Bureau of the Taiwan Financial Supervisory Commission during the period from 1995 to 2011. Data frequency is annual. This paper focuses on the sustainability of bank performance. As such, the survival time of the bank is the research emphasis. To prevent error and bias, the combined data or the data of recently founded banks will be deleted. The statistics show that 18 banks, which are listed in Table 1, met the research requirement for survival time.

Table 1: Sample bank

Bank name	Symbol	Bank name	Symbol
1.BANK OF TAIWAN	BOT	10.UNION BANK OF TAIWAN	UBT
2.LAND BANK OF TAIWAN	LBOT	11.E.SUN COMMERCIAL BANK	ECB
3.TAIWAN COOPERATIVE BANK	TCB	12.COSMOS BANK	CB
4.FIRST COMMERCIAL BANK	FCB	13.TAISHIN BANK	TSB
5.HUA NAN BANK	HNB	14.TC BANK	TB
6.CHANG HWA BANK	CHB	15.ENTIE COMMERCIAL BANK	EB
7.THE SHANGHAI COMMERCIAL & SAVING BANK	SCSB	16.CTBC BANK	CT
8.CATHAY UNITED BANK	CUB	17.TAIWAN BUSINESS BANK	TBB
9.BANK OF KAOHSIUNG	BOK	18.TAICHUNG COMMERCIAL BANK	TAB

Sample bank shows the survival bank from 1995 to 2011.

This paper selects the input and output variables as well as adopts the intermediation approach to regard interest expense, personnel expense, and operating expense as input items and deposit, investment, and all loans as output items. The empirical descriptive statistics shows that all variables are distributed in nonsteady state, and most of them are positively skewed, that is, the main body of distribution focuses on the left, with a longer tail to the right. This circumstance is also called skewed to the right. In terms of kurtosis, variables are leptokurtic. Finally, variable dispersion analysis showed that the dispersion of personnel expense in each bank is the smallest and the dispersion of loan is the largest, as shown in Table 2.

Table 2: Sample statistics

	Interest expense	**Salary expense**	**Operating expense**	**Deposit**	**Loans**	**Investment**
Mean	19234.85	5044.157	14753.14	117733.2	575608	22532.46
Median	10752	4345.5	9297.5	69369	478222	7469
Maximum	89168	15732	342803	1275188.	2171539.	308853
Minimum	1084	403	740	5568	50671	0.0000
Std. Dev.	19123.23	3621.614	26740.56	151523.8	484392.7	37253.6
Skewness	1.5359	0.5233	7.9009	3.3021	1.0210	3.0953
Kurtosis	4.7519	2.2160	85.1869	19.4229	3.4439	16.8571
Jarque-Bera	159.4461	21.8033	89306.07	3994.950	55.6774	2936.893
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Measured in millions of l NT Dollars, Number of observations: 306.

3.3 DEA Efficiency Coefficient

The efficiency obtained from fixed returns to scale is TE. The efficiency from flexible returns to scale is PTE. In addition, SE is $SE = TE/PTE$ and technical and scale efficiency is $TSE = SE \times TE$. If TSE is larger, then the units to be evaluated have improved development performance during this period. TE aims to evaluate if this institution uses minimal investment resources under the fixed output. SE aims to measure if banks are in the most suitable scale operation, namely, to study if banks operate under fixed returns to scale. Based on this description, this paper sets the mode to super SBM output-oriented fixed scale mode by using the DEA-SOLVER software to obtain TE and the flexible scale mode to obtain PTE. Then, SE is obtained through a mathematical operation.

Table 3 shows the empirical results of the panel descriptive statistics of various banks in the past 17 years. As shown in the table, the average value of PTE is higher than that of TE and SE. Returns to scale reflect the ratio of the increasing output under increased investments. Overall, Taiwan’s banking industry is in a decreasing scale, that is, the ratio of the increasing output is less than that of the increased investment.

Table 3: DEA efficiency scores statistics

Efficiency scores	Mean	Standard deviation
SSBM-TE	0.7015	0.4769
SSBM-PTE	0.9002	0.4769
SSBM-SE	0.7585	0.2935

Notes:1.SSBM(Super Slack-Based Measure). 2.TE(Technical Efficiency). 3.PTE(Pure Technical Efficiency). 4.SE(Scale Efficiency). 5. Number of observations:306.

This paper adopts the non-ray estimation method and considers the difference between input and output at the same time. When the efficiency value of DMU is greater than 1, no differences in the input or output of DMU in the production boundary are observed. The output-oriented TE aims to investigate how much output DMU can expand in equal ratio without changing investments to reach TE. In particular, we compare the output results to determine if investments are the same. Table 4-8 shows that the relative TE of BOT is the best. The highest level is maintained during the sampling period, namely, 17 years. The LBOT follows, with the relative TE reaching the highest level in 16 years. The analysis shows that these two banks are characterized by the acting national treasury business as agent, high official stock, high net assets, and unlisted equity. As such, BOT and LBOT are high-quality banks with steady growth and treasury deposit. Moreover, the relative TE of the TCB reached the standard level during the sampling period within a long time of up to 13 years. Only the efficiency value in 2006 is relatively poor, which may be related to bank mergers. After being incorporated with Agricultural Bank in 2005, the TCB could not synchronously review the establishment of branches. Two TCB have branches in the same area, which is inconsistent with the concept of efficiency cost. Thus, invalid results have been produced for many years. The SCSB performs best among the private banks. Except for its inability to achieve the required efficiency 4 years ago, the SCSB relative TE reached the standard level for 13 consecutive years since 1999. In addition, the SCSB relative efficiency value is higher than that of BOT and LBOT. The high relative efficiency value indicates that the management of the private banks should have a flexible application and adjustment mechanism in the regulation and response of operating performance. The operating performance of TAB reached the standard in the past 8 years probably because the board of directors of the bank modified its practice in 2003. The performance of TAB has improved since 2004, which makes TAB a high-quality bank. The banks with the worst overall operating performance TE are CB, TSB, and CT. These banks' technical efficiencies in operating performance are invalid during the sampling period. The analysis shows that the invalid technical efficiencies in operating performance may have been the result of bank operating directions that are different from the traditional bank mode and focus on credit cards. Therefore, the bank's performance is not what we expected when compared with traditional bank performance.

With some convexity restrictions, the PTE can cover the data points tightly. The difference from TE is called SE. The empirical result shows that approximately 13 of 18 sample banks have high performance above the level of PTE during the sampling period. The PTE of banks is mostly higher than the TE. As such, the performance scale efficiencies of BOT and other banks failed to reach the standard level. This result indicates that their scales of operating efficiency have reached the industry level. These banks should expand their operating scale and improve their productivity to enhance their TE. Thus, the SE value can reach the standard level. The study also shows that, with SE reaching the standard level from 2000 to 2005, the BOK belongs to the types of progressively increased returns to scale. The analysis shows that the BOK changed from public to private bank during this period. The bank has positively improved its operating mechanism and expanded to become a national bank. Therefore, increasing returns to scale are obtained. The TE of this bank has been low since 2006. As such, the management should be improved.

Banks have different performances in economies of scale in different years. Deciding how decision makers regulate and respond to management is difficult. Practically, immediately adjusting the size of the scale in response to performance in the economies of scale is infeasible[7]. However, banks generally set their goals, strategically adjust their operating scale, and inspect if resource applications are irresponsibly used, which results in inefficiency. Banks should moderately downsize scale, enhance asset utilization efficiency, or improve the strategies of branches and departments with poor performance to reduce the average long-term operating cost.

Table 4: Individual bank's performance from Super SBM model from 1995—1998

		1995			1996			1997			1998	
DMUS	**TE**	**PTE**	**SE**	**TE**	**PTE**	**SE**	**TE**	**PTE**	**SE**	**TE**	**PTE**	**SE**
BOT	1.1662	1.2594	0.9260	1.0393	1.0656	0.9753	1.1627	1.3400	0.8677	1.1734	1.3644	0.8600
LBOT	1.0334	1.0353	0.9982	1.0118	1.0243	0.9879	0.7884	0.8078	0.9759	0.7737	0.7742	0.9994
TCB	1.2672	1.2950	0.9786	1.4137	1.5321	0.9227	1.2376	1.2451	0.9940	1.2859	1.2923	0.9951
FCB	0.6951	0.6958	0.9990	0.7241	0.7386	0.9804	0.7051	0.7615	0.9260	0.6751	0.6761	0.9986
HNB	0.7951	0.7960	0.9989	0.7703	0.8426	0.9142	0.7794	0.8612	0.9051	0.8552	0.8577	0.9970
CHB	0.7827	0.7835	0.9989	0.7471	0.7901	0.9456	0.7872	0.8190	0.9612	0.6838	0.6898	0.9913
SCSB	0.7274	0.7329	0.9925	0.8206	0.8454	0.9707	0.8421	0.8473	0.9939	0.8103	0.9212	0.8796
CUB	1.0145	1.0204	0.9942	1.1147	1.1321	0.9846	1.1329	1.1783	0.9615	1.1128	1.1215	0.9922
BOK	1.0274	1.0000	1.0274	1.0035	1.0000	1.0035	0.7467	1.0000	0.7467	0.7858	1.0000	0.7858
UBT	0.8210	0.8368	0.9811	0.7327	0.8249	0.8881	0.7989	0.8511	0.9387	0.6790	0.7525	0.9024
ECB	1.0119	1.1518	0.8786	1.0397	1.3964	0.7445	1.0243	1.1705	0.8751	1.0392	1.0000	1.0392
CB	0.7474	0.7585	0.9854	0.7328	0.8261	0.8870	0.7655	0.7985	0.9587	0.7309	0.8983	0.8136
TSB	0.7986	0.8183	0.9759	0.7208	0.7726	0.9330	0.8769	0.8797	0.9968	0.5909	0.7116	0.8304
TB	0.8063	0.8200	0.9832	0.8567	0.8895	0.9632	0.7092	0.8100	0.8756	0.5813	1.0000	0.5813
EB	1.0483	1.0000	1.0483	1.0401	1.0000	1.0401	1.0432	1.0000	1.0432	1.0128	1.0000	1.0128
CT	0.7321	0.7388	0.9910	0.6893	0.7122	0.9678	0.7788	0.7871	0.9894	0.5800	0.5990	0.9682
TBB	0.7409	0.7427	0.9977	0.7063	0.8098	0.8722	0.7717	0.8819	0.8750	0.7887	0.7889	0.9998
TAB	0.9272	1.0139	0.9144	1.0232	1.0321	0.9913	0.9916	1.0983	0.9028	0.9364	0.9501	0.9856

Notes: 1. SSBM(Super Slack-Based Measure). 2. TE(Technical Efficiency). 3. PTE(Pure Technical Efficiency). 4. SE(Scale Efficiency).

[7]The establishment and cancellation of branches in Taiwan's banking industry shall be approved by the Ministry of Finance.

Table 5: Individual bank's performance from Super SBM model from 1999—2002

	1999			2000			2001			2002		
DMUS	**TE**	**PTE**	**SE**	**TE**	**PTE**	**SE**	**TE**	**PTE**	**SE**	**TE**	**PTE**	**SE**
BOT	1.3890	1.6279	0.8532	2.3141	2.4720	0.9361	2.0822	2.2340	0.9320	1.8453	1.9127	0.9647
LBOT	1.0291	1.0753	0.9570	1.0033	1.0129	0.9905	1.0065	1.0251	0.9819	1.0341	1.0407	0.9936
TCB	1.1970	1.2014	0.9963	1.0133	1.0165	0.9968	1.0111	1.0377	0.9744	1.0083	1.0684	0.9437
FCB	0.8905	1.0029	0.8879	1.0455	1.0473	0.9983	0.7807	0.9504	0.8214	1.0668	1.0911	0.9778
HNB	0.8326	0.8843	0.9415	1.0026	1.0084	0.9942	1.0546	1.0604	0.9945	0.2686	0.7237	0.3712
CHB	1.0110	1.0116	0.9994	0.4668	0.6080	0.7678	1.0020	1.0029	0.9990	0.2318	1.0308	0.2248
SCSB	1.2474	1.4441	0.8638	1.2012	1.4368	0.8360	1.3536	1.6655	0.8127	1.6233	1.8728	0.8668
CUB	0.8681	0.8779	0.9888	0.7853	0.7854	0.9999	0.7004	0.7491	0.9349	1.0907	1.0908	0.9999
BOK	0.3070	1.0000	0.3070	1.0138	1.0000	1.0138	1.0794	1.0000	1.0794	0.4028	1.0000	0.4028
UBT	0.5757	0.7976	0.7218	0.3709	0.5689	0.6520	0.3228	1.0000	0.3228	0.2350	1.0000	0.2350
ECB	1.0043	1.0000	1.0043	1.0117	1.0121	0.9996	0.7264	0.7385	0.9836	0.4181	0.5293	0.7900
CB	0.5152	0.7718	0.6676	0.3632	0.8643	0.4203	0.4566	0.9121	0.5006	0.1153	0.1557	0.7408
TSB	0.4812	0.5557	0.8660	0.5537	0.5561	0.9958	0.3551	0.4031	0.8809	0.3216	0.3231	0.9953
TB	0.7840	1.0000	0.7840	0.5481	1.1365	0.4823	0.5769	1.0000	0.5769	0.3742	1.0768	0.3475
EB	1.0242	1.0000	1.0242	0.7324	1.0000	0.7324	0.4180	0.6482	0.6448	0.4049	1.0000	0.4049
CT	0.4719	0.4894	0.9643	0.3149	0.3593	0.8765	0.2361	0.2891	0.8169	0.3477	0.5102	0.6815
TBB	1.0475	1.0547	0.9931	1.0391	1.0440	0.9954	0.5065	0.5865	0.8637	1.0805	1.0849	0.9960
TAB	0.0544	1.0000	0.0544	0.0530	0.2278	0.2327	0.0630	1.0000	0.0630	0.1145	1.0000	0.1145

Notes: 1. SSBM(Super Slack-Based Measure). 2. TE(Technical Efficiency). 3. PTE(Pure Technical Efficiency). 4. SE(Scale Efficiency).

Table 6: Individual bank's performance from Super SBM model from 2003—2006

	2003			2004			2005			2006		
DMUS	**TE**	**PTE**	**SE**	**TE**	**PTE**	**SE**	**TE**	**PTE**	**SE**	**TE**	**PTE**	**SE**
BOT	1.5856	1.7882	0.8867	1.9276	1.9598	0.9835	2.0060	2.0441	0.9814	1.2099	1.7246	0.7016
LBOT	1.0520	1.0546	0.9975	2.1389	4.5376	0.4714	1.0310	1.0625	0.9703	0.0022	0.0053	0.4263
TCB	1.0863	1.1515	0.9433	1.1080	1.1084	0.9997	1.0396	1.0400	0.9996	1.1926	1.2958	0.9204
FCB	0.6139	1.2427	0.4940	0.7196	1.0655	0.6753	0.7118	1.0598	0.6717	0.1123	0.2911	0.3859
HNB	1.0522	1.0562	0.9963	1.0154	1.1490	0.8837	0.9086	1.2280	0.7399	0.0576	1.0152	0.0567
CHB	1.0143	1.0234	0.9911	1.0105	1.0623	0.9512	0.3430	1.0856	0.3159	0.0086	0.0086	1.0064
SCSB	1.5328	1.8589	0.8246	1.5679	1.6919	0.9267	1.4587	1.5918	0.9164	1.5542	1.6913	0.9189
CUB	1.0936	1.0962	0.9976	0.6676	1.0511	0.6352	1.0837	1.1802	0.9182	0.1634	0.2645	0.6178
BOK	1.0044	1.0000	1.0044	1.0220	1.0000	1.0220	1.0209	1.0000	1.0209	0.1189	1.0000	0.1189
UBT	0.2577	0.5124	0.5030	0.2619	0.2990	0.8760	0.3599	0.3897	0.9236	0.2475	0.2703	0.9158
ECB	0.5232	0.5999	0.8721	0.5892	0.6075	0.9699	1.0442	1.0504	0.9941	0.0159	0.0210	0.7584
CB	0.1872	0.2053	0.9117	0.1513	0.1589	0.9519	0.2645	0.3159	0.8371	0.0062	0.0085	0.7320
TSB	0.1901	0.3062	0.6207	0.1722	0.2812	0.6125	0.1707	0.2752	0.6204	0.0914	0.1841	0.4964
TB	1.0001	1.0089	0.9913	0.1830	0.1839	0.9952	0.2809	0.3124	0.8991	0.2120	0.2173	0.9753
EB	0.4380	1.0392	0.4215	1.0191	1.0316	0.9879	1.0028	1.0603	0.9458	1.0846	2.9929	0.3624
CT	0.4204	0.7366	0.5708	0.3114	0.6261	0.4974	0.3043	0.5795	0.5250	0.3137	0.6480	0.4840
TBB	1.0126	1.0144	0.9982	0.0910	0.2005	0.4536	0.1893	1.0103	0.1874	0.0348	0.0388	0.8960
TAB	0.0629	0.0638	0.9874	1.0161	1.0254	0.9909	1.0737	1.1040	0.9725	1.1869	1.3078	0.9076

Notes: 1. SSBM(Super Slack-Based Measure). 2. TE(Technical Efficiency). 3. PTE(Pure Technical Efficiency). 4. SE(Scale Efficiency).

Table 7: Individual bank's performance from Super SBM model from 2007—2010

	2007			2008			2009			2010		
DMUS	**TE**	**PTE**	**SE**	**TE**	**PTE**	**SE**	**TE**	**PTE**	**SE**	**TE**	**PTE**	**SE**
BOT	1.2362	1.9665	0.6286	1.2841	1.9052	0.6740	1.3833	2.0060	0.6896	1.1375	1.7924	0.6346
LBOT	1.0497	1.0521	0.9977	1.3031	1.3499	0.9653	1.1565	1.1577	0.9990	1.1064	1.1081	0.9985
TCB	1.0205	1.1143	0.9158	0.2711	1.1126	0.2437	0.2376	1.0193	0.2331	0.2380	1.0026	0.2374
FCB	0.0736	0.2394	0.3072	0.1234	1.0194	0.1211	0.0877	0.2360	0.3715	0.0755	0.4529	0.1668
HNB	0.0412	1.0267	0.0401	0.0281	1.0000	0.0281	0.0082	0.0260	0.3139	0.0059	0.0503	0.1170
CHB	0.0085	0.0136	0.6249	0.0596	1.0097	0.0590	0.0086	0.0231	0.3726	0.0059	0.0339	0.1730
SCSB	1.5723	1.6882	0.9314	1.4754	1.4861	0.9928	1.5382	1.5434	0.9967	1.6661	1.6788	0.9924
CUB	1.0922	1.1664	0.9364	1.0786	1.1090	0.9726	1.0904	1.1001	0.9912	0.1192	0.3606	0.3305
BOK	0.0750	1.0000	0.0750	0.3648	1.0000	0.3648	0.0132	1.0000	0.0132	0.0110	1.0000	0.0110
UBT	0.2141	0.2321	0.9222	0.1942	0.2303	0.8430	0.2720	0.3924	0.6931	0.1577	0.1755	0.8989
ECB	0.0254	0.0623	0.4082	0.8834	0.9424	0.9374	0.9091	0.9140	0.9947	0.4455	0.5592	0.7966
CB	0.0073	0.0228	0.3193	0.0085	0.0313	0.2720	0.0027	0.0063	0.4216	0.0139	1.0000	0.0139
TSB	0.1148	0.1977	0.5805	0.0557	0.1054	0.5286	0.0585	0.0931	0.6285	0.0712	0.1272	0.5595
TB	0.2576	0.2671	0.9644	0.1768	0.1970	0.8974	0.1360	0.1563	0.8704	0.0841	0.0906	0.9287
EB	0.3725	1.5683	0.2375	0.2372	1.3341	0.1778	0.2711	1.1819	0.2294	1.1352	1.1789	0.9629
CT	0.3495	0.6552	0.5334	0.3366	0.7140	0.4715	0.3220	0.5188	0.6206	0.3667	0.8238	0.4451
TBB	1.0050	1.0200	0.9854	1.0093	1.0091	1.0001	0.0066	0.0108	0.6093	0.0015	0.0054	0.2694
TAB	1.0671	1.2234	0.8723	1.1331	1.2137	0.9336	1.0089	1.0563	0.9551	1.1441	1.1867	0.9641

Notes: 1. SSBM(Super Slack-Based Measure). 2. TE(Technical Efficiency). 3. PTE(Pure Technical Efficiency). 4. SE(Scale Efficiency).

Table 8: Individual bank's performance from Super SBM model from 2011

DMUS	**TE**	**PTE**	**SE**	DMUS	**TE**	**PTE**	**SE**	DMUS	**TE**	**PTE**	**SE**
BOT	1.1631	1.8401	0.6321	SCSB	1.4866	1.5891	0.9355	TSB	0.0738	0.1275	0.5791
LBOT	1.2922	1.3703	0.9430	CUB	0.1947	0.3800	0.5123	TB	0.1178	0.1526	0.7724
TCB	0.1244	1.1172	0.1114	BOK	0.0222	1.0000	0.0222	EB	1.0890	1.2102	0.8998
FCB	0.2648	1.0050	0.2635	UBT	1.0534	1.0743	0.9805	CT	0.4553	1.0002	0.4551
HNB	0.0239	0.2683	0.0890	ECB	0.4706	0.5297	0.8884	TBB	0.0045	0.0074	0.6067
CHB	0.0973	1.0053	0.0968	CB	0.0115	1.0000	0.0115	TAB	1.1707	1.2363	0.9470

Notes: 1. SSBM(Super Slack-Based Measure). 2. TE(Technical Efficiency). 3. PTE(Pure Technical Efficiency). 4. SE(Scale Efficiency).

3.4 Panel Unit Root Test

Bank efficiency can undergo a lag period through financial innovation, and a dynamic efficiency under the framework is observed (Wang and Huang, 2007). Therefore, three efficiencies in Taiwan's banking industry for each year are combined with panel data to enable analysis of dynamic efficiency. The consequent time series data can be used to reveal the relationship between the past and the present, and predict the trend of efficiency in the future, thus providing decision makers with reference in advance. When considering the equilibrium conditions of the cobweb theorem, the data pattern must have stability and be in the steady state. Under long-term equilibrium, error has counteraction. If the expected value is zero, then we can investigate the possibility of the message of the previous stage until the next stage. As such, we must inspect if the data is in steady state before conducting the study.

To inspect the occurrence of error, this paper adopts four different panel unit root tests to conduct the inspection. The empirical result shows that TE, PTE and SE are in steady state and pass three of the four panel unit root tests[8]. The results are shown in Table 9. Therefore, we can deduce that all efficiency values are not dispersed and have convergent and steady-state features.

Table 9: Panel unit root

efficiency scores	**L.L.C.**	**I.P.S**	**ADF**	**PP**
SSBM-TE	0.0089***	0.1611	0.0045***	0.0002***
SSBM-PTE	0.0001***	0.0148**	0.0398**	0.0011***
SSBM-SE	0.0006***	0.1761	0.0437**	0.0271**

***, **, and * indicate significance at the 0.01, 0.05 and 0.1 levels, respectively.

This section has confirmed that all efficiency values are in steady state, with convergent sustainability. The deferred circumstances of efficiency sustainability are not AR (1) and possibly contain intertemporal or multistage deferment. To completely determine the efficiency-deferred result, stepwise regression is used to screen the optimal lag period for all efficiency values. As shown in Table 10, the empirical result shows that the optimal lag periods for the TE value are Periods 1 and 4, the optimal lag periods for the PTE value are Periods 1 and 3, and the optimal lag periods for the SE value are Periods 1 and 2. These results meet the expectation of intertemporal or multistage deferment and verify the finding of Wang and Huang (2007) that the dynamic sustainability of efficiency in only one lag period is insufficient.

Table 10: Panel stepwise regression

efficiency scores	**AR(1)**	**AR(2)**	**AR(3)**	**AR(4)**
SSBM-TE	0.6560***			0.2637***
SSBM-PTE	0.4840***		0.3386***	
SSBM-SE	0.5887***	0.1360**		

***, **, and * indicate significance at the 0.01, 0.05 and 0.1 levels, respectively.

3.5 Panel Data Model

This paper adopts the panel-estimated AR model to conduct the empirical analysis. Data of the panel-estimated AR model have two characteristics, namely, time series and cross-section. With these two characteristics, this paper focuses on the dynamic sustainability of each efficiency value of Taiwan's banks. The empirical result in Table 11 shows that the sustainability of TE is up to 90.56%, the sustainability of PTE is up to 94.42%, and the sustainability of SE is approximately 83.18% (89.39% on average). Therefore, these results verify that the changes in operating efficiency value will be relatively reflected in several lag periods when the banking industry gradually adjusts its operating scale. That is to say, the operating efficiency has a certain dynamic sustainability.

We observed from the aforementioned results that if other endogenous variables and

[8]Levin,Lin and Chu(2002)L.L.C Unit Root Test . Im,Pesaran and Shin(2003)I.P.S Unit Root Test. Said and Dickey (1984) augmented Dickey-Fuller (ADF) Test. Phillips and Perron (1988) P.P Unit Root Test.

environmental variables are used to explain the changes in all efficiencies, then the highest explanatory ability is only 10.61%. This result does not meet the cost of analysis, with low reference value.

Table 11: Panel data

	SSBM-TE	SSBM-PTE	SSBM-SE
C	0.0053	0.0480	0.1070***
AR(1)	0.7351***	0.6474***	0.6624***
AR(2)			0.1694***
AR(3)		0.2968***	
AR(4)	0.1705***		
R-squared	0.7197	0.7217	0.5645
Efficiency Persistence	0.9056	0.9442	0.8318

*** indicate significance at the 0.01 levels, respectively.

After investigating the dynamic sustainability of the operating efficiency value of Taiwan's banking industry, we further analyze the sustainability of the individual efficiency of all DMUs. As shown in Table 12, BOT, LBOT, and SCSB have optimal sustainability of TE, whereas CB and TB have the worst sustainability. An analysis of the reasons for this finding indicates that if the bank has better performance efficiency, then its efficiency sustainability is higher, otherwise, its efficiency sustainability is lower. However, the analysis of the sustainability of individual bank SE shows that the efficiency sustainability of each bank is not different possibly because the PTE of Taiwan's banks has reached a considerable level. As such, the change in SE is not more significant than TE before the operating scale failed to effectively extend.

Table 12: Individual bank's efficiency persistence

DMUS	SSBM-TE	SSBM-SE	DMUS	SSBM-TE	SSBM-SE
BOT	0.9265	0.7855	UBT	0.6415	0.7831
LBOT	0.9080	0.8148	ECB	0.7078	0.8111
TCB	0.8254	0.7738	CB	0.4367	0.7012
FCB	0.7669	0.6960	TSB	0.7546	0.7457
HNB	0.7098	0.6828	TB	0.5288	0.7728
CHB	0.6255	0.6529	EB	0.8133	0.6999

4 Conclusions and Suggestions

This paper used the DEA approach to assess the operating efficiency of 18 banks in Taiwan. Referring to previous literature, this paper adopts the intermediation approach to select the input and output variables. Deposits, investments, and all loans are selected as output items, and interest expense, personnel expense, and operating expense are selected as input items. Based on the DEA estimation result, the following conclusions can be made:

1.BOT and LBOT have the optimal relative TE value. The TE of TCB decreased because of bank incorporation. For private banks, SCSB has the best performance. Except for the efficiency value, which failed to reach the standard level 4 years ago, SCSB relative TE has reached the standard level for 13 consecutive years and is higher than that of BOT and LBOT. This result shows that managers can make flexible applications. After the board of

directors of TAB changed its operating practice in 2003, the TE of its 8 consecutive-year operating performance is efficient. As such, TAB is a high-quality bank.
2.CB, TSB, and CT are three private banks that have the worst TE of operating performance. Their performances are inefficient during the sampling period. Private banks with a flexibly changed operating mode focus on management for profits. As such, these banks do not tolerate poor operating performance. Therefore, CB, TSB, and CT are different from other banks. They do not act solely as intermediate institutions for financial service but also use diversified operating modes to create bank profit growth.
3.For PTE, the empirical result shows that the performances of most banks reached PTE, that is, the expanding operating scale can effectively improve SE.
Banks have different economies of scale performances in different years. In practice, decision makers cannot immediately adjust the scale for the corresponding economies of scale performances annually. However, they can determine the direction of their response to government direction and strategically adjust the operating scale, thus reaching the standard SE level.
This paper aimed to investigate the sustainability of all efficiency values, and the following conclusions are made:
1.All efficiency values have intertemporal or multistage deferred dynamic sustainability. These efficiency values can be used to improve upon the limitations of previous studies and explain the dynamic sustainability of efficiency with a lag period.
2.The average sustainability of all efficiency values is up to 89.39%. This value indicates that when the banking industry gradually adjusts its operating scale, the changes in operating efficiency will be relatively reflected in several lag periods. In other words, the operating efficiency has a certain dynamic sustainability.
3.If other endogenous variables and environmental variables are used to explain the changes in all efficiencies, then the highest explanatory ability is only 10.61%. This result does not meet the cost of analysis and has low reference value.
4.Individual banks are used to analyze the sustainability of TE. BOT, LBOT, and SCSB show optimal sustainability of TE, and CB and TB have the worst sustainability of TE. This finding indicates that if the bank has better performance efficiency, then its efficiency sustainability is higher. If the PTE of Taiwan's banks reached a considerable level, then the change in SE is not more significant than TE before the operating scale failed to extend effectively.

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